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Information Science and Technology Center Seminar

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"A Nonlinear Coding Scheme in the Early Visual System"

Wednesday, August 25, 2010
3:00 - 4:00 PM
TA-3, Bldg. 1690, Room 102 (CNLS Conference Room)

Abstract: Characterizing the coding strategies used by a sensory system is a fundamental goal in neuroscience research. Attaining this goal has particularly important implications for applied sciences, which can translate neural coding strategies into models for solving vexing problems such as automated object recognition. In the realm of visual processing, much of the existing experimental work has focused on characterizing the coding principles of a visual pathway originating at the retina known either as the X-cell or parvocellular pathway. The responses of X-cells are dominantly linear and well-modeled using linear spatiotemporal filters similar to those at the front-end of many computer vision systems. There exists a second major visual pathway originating at the retina known either as the Y-cell or magnocellular pathway. The responses of Y-cells are known to be nonlinear; however, the principles by which they encode the visual scene are poorly understood. Identifying these principles is a necessary first step toward translating the Y-cell pathway into a model with practical applications involving computer vision.

As such, the goal of the present study is to functionally identify the nonlinear coding scheme underlying the responses of Y-cells. This work advances a recent publication by the presenter demonstrating that Y-cells account for nonlinear response properties previously measured in and thought to arise in cortex (Rosenberg et al., 2010). Electrophysiological recordings of individual Y-cells were made in the cat lateral geniculate nucleus, the subcortical target through which visual information is passed from the retina to cortex. Using techniques from Fourier analysis, the nonlinear coding scheme of the Y-cell pathway is identified in the present study as demodulation, a nonlinear engineering principle with numerous applications including the decoding of AM radio signals. It is shown that the Y-cell pathway is in many regards anatomically and functionally similar to the demodulating circuit in an AM radio receiver. Although the importance of visual demodulation is not well understood at this time, existing theoretical work suggests that demodulation is an efficient way to encode texture patterns important for pattern recognition and boundary detection. Examples demonstrating this will be presented. In addition, the present results have important implications relating visual acuity and the manner in which temporally varying stimuli are encoded in the visual system. Having identified the nonlinear coding scheme as demodulation allows for straightforward modeling of the Y-cell visual pathway. Such a model will not only provide a way to systematically study the role of this nonlinear coding scheme in visual processing but also enable solutions to real-world image processing problems.

Rosenberg A., Husson, T.R., & Issa, N.P. *Subcortical representation of non-Fourier image features.* Journal of Neuroscience, 30(6): 1985-1993, 2010.

Biography: Ari Rosenberg, Ph.D., is currently a post-doctoral scholar at the Washington University School of Medicine in St. Louis where he is conducting physiological studies on the neural mechanisms underlying the representation of three-dimensional orientation. He received his Ph.D. in Computational Neuroscience from the University of Chicago where as a Department of Homeland Security Fellow he studied visual processing using physiological and psychophysical methods. A key achievement of his graduate school work was the functional characterization of a nonlinear processing stream in the early visual system. As a Department of Homeland Security Scholar, he received his B.A. in Liberal Arts and Sciences with an Honors concentration in Cognitive Science from the Wilkes Honors College of Florida Atlantic University. A key achievement of his undergraduate work was publication of a study using latent structure analysis to characterize American sociopolitical attitudes following the September 11th attacks (Lanning & Rosenberg, 2009). Ari spent the summers of 2004 and 2006 at Los Alamos with Drs. Michael Cai and Karin Verspoor investigating the use of psychophysical and physiological indicators to infer concealed information, as well as on a physiological model of motion processing. To date he has published 5 research articles, 2 review articles, and 1 book chapter.

Lanning, K. & Rosenberg, A. *The dimensionality of American political attitudes: Tensions between equality and freedom in the wake of September 11.* Behavioral Sciences of Terrorism and Political Aggression, 1(2): 84-100, 2009.

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